EFFECTS OF ELEVATION ON FLOWER MORPHOLOGY AND DIVERSITY OF HUMMINGBIRD-POLLINATED PLANTS

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Abstract. The changing environmental stresses across different elevations may influence the diversity and flower morphology of hummingbird-pollinated plants. If so, we hypothesized (1) that the species diversity of such plants would decrease with increasing elevation, and (2) that flower morphologies within species common to both the high and low elevation sites would vary across the elevational gradient. Over a 340m elevational gradient at Cerro de la Muerte, we found lower diversity of hummingbird-pollinated plants at high elevation relative to low elevation. We found no difference in intraspecific flower morphology as indicated by visual qualitative assessments of petal color and corolla length between the high and low elevation sites. The changes in environmental stresses between the two sample elevations may be too small to cause ecotype differences or there may be a selective force, such as competition for pollinators, favoring conformity in intraspecific flower morphology.

INTRODUCTION

The stresses of a high elevation environment limit the number of species that can thrive at higher elevations. If only a few species dominate at higher elevations, diversity should decrease with increasing elevation. We hypothesized that the diversity of hummingbird-pollinated flowers would follow this elevational trend.

The changing physiological constraints across an elevational gradient may cause intraspecific genetic (ecotype) or phenotypic differences (Clausen et al. 1941). We hypothesized that these ecotype or phenotypic differences may appear as differences in flower morphology. If hummingbird-pollinated flower morphology changes with elevation, the plant species may attract different pollinator species, which might affect plant reproductive success. Variable reproductive success of hummingbird-pollinated species might help explain differences in diversity across an elevational gradient. To examine this, we studied hummingbird-pollinated plant diversity and compared intraspecific flower morphology at two mountain sites in Costa Rica, differing in elevation by 340m.

METHODS

We conducted our study on 26 January 1995 at two sites in Cerro de la Muerte, Costa Rica. The low elevation site (2600 m) was located along the dirt road 50m east of Cuerici Biological Station. The high elevation site (2940 m) was located along the dirt road to the Cuerici station, 200m from the Pan American Highway .

We sampled along a 200m x 5m belt transect on one side of the dirt road at each site. We recorded the number of individuals and the number of flowers per individual for all hummingbird-pollinated plants within each belt. At both sites, we collected 10 mature, fresh flowers from each hummingbird-pollinated species represented in the belt. If we found 10 or more individuals of one species within a belt, we collected one flower from each of 10 individuals. If we found less than 10 individuals of one species within a belt, we collected multiple flowers from each individual for a total of 10 flowers. We then visually, and qualitatively compared petal color and corolla length of species common to both low and high elevation sites.

TABLE 1. Species composition of hummingbird-pollinated plants in a 1,000m^2 plot near Cuerici Biological Station ("low elevation"), Cerro de la Muerte

Species	number of individuals	percent of total individuals	total number of flowers	mean number of flowers/ individual ± SE	percent of total flowers
Fuchsia sp.	43	56.6	15,341	357 ± 57	87.5
Ericaceae sp.	5	6.6	616	123 ± 31	3.5
Bomarea sp. A	21	27.6	943	45 ± 10	5.4
Bomarea sp. B	4	5.3	69	17 ± 7	0.4
Centropogon valerii	1	1.3	49	49	0.2
Gesneriaceae sp.	2	2.6	520	260 ± 20	3.0
TOTAL	76	100	17,538	--	100

TABLE 2. Species composition of hummingbird-pollinated plants in a 1,000m^2 plot near the Pan American Highway ("high elevation"), Cerro de la Muerte

Species	number of individuals	percent of total individual	total number of flowers	mean number of flowers/ individual ± SE	percent of total flowers
Fuchsia sp.	2	2.7	106	53 ± 33	0.6
Ericaceae sp.	57	78.1	17,979	315 ± 40	98.4
Bomarea sp. C	8	11	152	19 ± 3	0.8
Centropogon sp.	4	5.5	19	5 ± 1	0.1
Unknown sp.	2	2.7	7	4 ± 1	0.1
TOTAL	73	100	18,263	--	100

RESULTS

We found five species of hummingbird-pollinated plants at the high elevation site and six species at the low elevation site. Species richness was thus similar at both sites (Tables 1 and 2). However, species diversity, as calculated by the Shannon-Weiner diversity index (which takes into account both species richness and relative abundances), was lower at the high elevation site (0.79) than at the low elevation site (1.16).

Fuchsia sp. and Ericaceae sp. were the only species common to both high and low elevation sites (Tables 1 and 2). The flower morphologies of *Fuchsia* sp. and Ericaceae sp., determined by flower color and length, appeared by visual inspection to be the same at both high and low elevation sites.

DISCUSSION

As predicted, we found a lower diversity of hummingbird-pollinated species at the higher elevation. The lower temperatures, stronger winds and higher sun exposure at higher elevations was expected to limit the number of species that can thrive at higher elevations. Therefore, a relatively small number of species adapted to the harsher environment should dominate at higher elevations. Species richness was similar between the two elevations, but species evenness was more skewed at the higher elevation, with Ericaceae sp. dominating far above all other species (Table 2). *Fuchsia* sp. was the most abundant hummingbird-pollinated species at the lower elevation, but *Bomarea* sp. A was also fairly abundant at the lower elevation (Table 1). The greater unevenness of species distribution at the higher elevation explains the lower diversity at that elevation.

We found no obvious intraspecific differences in flower morphology between the lower and higher elevations for either the *Fuchsia* or the Ericaceae species based petal color and corolla length. The flower morphologies of these two species do not reflect potential ecotype differences. The elevational and habitat differences between the two study sites may be too

small to cause ecotype differences in plants common to both sites.

If a hummingbird-pollinated species has a specialist pollinator common to both lower and higher elevations, then selection might favor conformity in flower morphologies to enhance reproductive success. Specialist pollinators rely on specific flower morphologies for visual recognition. Changes in flower structure, such as increased corolla length, might reduce a specialist pollinator's ability to locate the flower and effectively pollinate it. Future studies should investigate pollinator species composition at both elevations at Cerro de la Muerte. If the *Fuchsia* or the Ericaceae species has a specialist pollinator common to both elevations, this may explain the observed conformity in flower morphology.

LITERATURE CITED

Clausen, J., D. D. Keck, and W. H. Hiesey. 1941. Experimental studies on the nature of species, IV Genetic Structure of Ecological Races. Carnegie Institute of Washington Publication, No. 242. Washington D.C.